How knowledge enables governance

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How knowledge enables governance: The coproduction of environmental governance capacity

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ABSTRACT

The creation and mobilization of knowledge are key issues in environmental governance. Consequently, understanding the roles that knowledge may play in governance is crucial for enabling well-informed governance arrangements. An aspect of knowledge-governance interactions that has received relatively little focused attention is that knowledge can be understood to be an intrinsic element of environmental governance. This paper aims to further the theoretical and empirical insight into this aspect. In order to do so, it elaborates a framework that conceptualizes various governance capacities, i.e. regulatory, adaptive, and integrative capacity, in terms of the coproduction of knowledge, values, and social order. This framework is applied in the analysis of three domains of governance that notably concern the management of the Dutch Wadden Sea area. The findings suggest that settling disputes about natural resources, and working towards a sustainable equilibrium between conserving and utilizing nature, may be enabled by means of interactive and flexible governance arrangements that complement centralized governance. Moreover, knowledge may constitute the governance capacities that are needed for reaching such an equilibrium in various ways: as a steering mechanism, as a key to learning, and as a connective element of governance. The findings indicate that enabling well-informed environmental governance is not just a matter of managing the interfaces between knowledge and governance, but also a matter of capacity-building in order to bring about reflexive governance arrangements.

1. Introduction

A key question in many domains of environmental management is how the conservation of the natural environment and the utilization of natural resources can be balanced in a sustainable way. A growing body of literature suggests that governance-oriented forms of environmental management may contribute to realizing such a balance. Environmental governance encompasses forms of collective decision-making and action that are aimed at protecting the environment and resolving conflicts over natural resources; it usually entails the active involvement of both governmental and non-governmental actors (Paavola, 2007; Wallington et al., 2008; Tacconi, 2011; Driessen et al., 2012; Bixler, 2014).

The literature has widely acknowledged that the creation, mobilization, and utilization of knowledge are crucial issues with respect to environmental governance (e.g. Meffe & Viederman, 1995; Giebels et al., 2013; Lemos, 2015). For instance, environmental governance may involve informing decision-making on environmental change, bringing together a variety of scientific and other knowledges, and dealing with knowledge disputes that may exist between various groups of stakeholders (Burns & Stöhr, 2011; Evans et al., 2011; Armitage et al., 2015; Runhaar et al., 2016). One aspect of knowledge-governance relations that has notably received attention in the literature is that realizing well-informed environmental governance requires managing the boundaries or interfaces that exist between knowledge and governance (Bremer & Glavovic, 2013; Clarke et al., 2013; Wesselink et al., 2013). Such boundary management may involve processes of boundary work, such as coordination work and knowledge exchange between experts and policy-makers (Robinson and Wallington, 2012; Jordan, 2014; Wyborn, 2015a).[1] Moreover, it may involve boundary organizations that "play an intermediary role between knowledge production and decision-making (in different domains and levels), with a view to achieving co-operation in relation to a shared objective (Clarke et al., 2013: 94; see also van Enst et al., 2016). The recent literature usually conceptualizes such boundaries and interfaces as dynamic, interactive, and socially constructed phenomena

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[1] The term boundary work was coined as an analytical concept that denotes the social and political work that is performed to grant epistemic authority to scientific knowledge, with an eye to demarcating it from non-scientific knowledges and activities (Gieryn, 1983). In the environmental governance literature it often has a slightly different connotation as it is used to denote knowledge management across boundaries (Turnhout et al., 2014).

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(Bäckstrand, 2004; Bremer & Glavovic, 2013; Wesselink et al., 2013; Janssen et al., 2015). In doing so it implicitly or explicitly dismisses the "linear model" that depicts the relation between knowledge-creation and policy-making as a one-way flow across a static boundary or gap. (Atkinson & Klausen, 2011; Hegger et al., 2012; O'Toole & Coffey, 2013; Wesselink et al., 2013; Wyborn, 2015a).

What has received less attention is that knowledge can also be seen as an intrinsic element of governance. This paper aims to further the theoretical and empirical insight into this aspect. Here, the term "intrinsic" signifies that performing environmental governance always involves knowledge in one way or another. In this paper I will operationalize this idea by means of a conceptual framework that combines the notion of governance as something that is constituted by a set of capacities (e.g., Termeer et al., 2013; Wyborn, 2015b) with the notion of the coproduction of knowledge and social order (Jasanoff, 2004).

The rationale behind this framework is twofold. Firstly, the framework distinguishes three key aspects of collaborative environmental governance. The first aspect is that environmental governance is a form of regulation that aims at reaching particular outcomes regarding the management or conservation of the environment (Lemos & Agrawal, 2006). The second aspect is that environmental governance often needs to deal with complex and dynamic processes in natural systems and with uncertainty on the effects of human interventions. Consequently, it has been argued that environmental governance arrangements need to be adaptive in order to be effective (Folke et al., 2005). The third aspect is that environmental governance usually includes a variety of governmental and non-governmental actors with diverging interests and perspectives. In order to enable collaborative action, such interests and perspectives need to be bridged or integrated (Raymond et al., 2010; Bohensky & Maru, 2011). From these three aspects may be inferred that performing environmental governance requires the capacities to regulate, adapt, and integrate. The next section provides a further operationalization of these three capacities on the basis of the environmental governance literature. Secondly, the rationale of the framework is that these three capacities encompass epistemic, normative, and social components. Accordingly, this paper conceptualizes the creation and application of these capacities as processes in which knowledge, values, and social order are produced together. In doing so, it builds on the work of Jasanoff (2004) and other scholars (e.g. Muñoz-Erickson, 2014; Chilvers & Kearnes, 2015; Wyborn, 2015b), who use the term *coproduction* to refer to this combined and interconnected production of knowledge, values, and social order. This application of the term is distinct from its usage to denote particular forms of collaborative knowledge creation (Hegger et al. 2012). I will use this framework to analyze how governance capacities were built and put into operation in three cases of coastal governance in the Netherlands. This analysis is notably focused towards identifying the roles of knowledge in relation to these capacities. This in turn may provide insight into the ways in which knowledge can be mobilized for building environmental governance capacity.

Section 2 provides an elaboration of the conceptual framework of coproduction and governance capacities. Subsequently, Section 3 describes the materials and methods and briefly introduces the three cases. Section 4 provides the empirical results; it describes how governance capacities were built and put into action in the cases, and focuses on the roles of knowledge in these processes. Finally, Section 5 provides a discussion and conclusion.

2. Conceptual framework

2.1. Coproduction

The term coproduction, as applied in the environmental governance literature, has two distinct meanings. Firstly, it is oftentimes used to denote a type of interactive or participatory process in which various groups of actors, such as experts, policy-makers, and stakeholders, collaboratively create knowledge (Berkes, 2009; Armitage et al., 2011; Edelenbos et al., 2011; Taylor & De Loë, 2012; Clarke et al., 2013). A second denotation of the concept, which is used in this paper, concerns the ways in which knowledge and social order are created together. In this second sense "co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it" (Jasanoff, 2004: 2). From this perspective "knowledge and its material embodiments are at once products of social work and constitutive of social life; society cannot function without knowledge any more than knowledge can exist without appropriate social supports" (Jasanoff, 2004: 2–3). Thus, in this sense knowledge and social order are constructed together in social practices and have a mutually constitutive relation. In recent environmental governance scholarship this second form of coproduction has been applied as an analytical framework, for instance in examining the interplay between knowledge and power dynamics in governance arrangements (Muñoz-Erickson, 2014). Moreover, it has been applied to conceptualize adaptive governance in terms of the "coproductive capacities" that "enable groups of actors to connect knowledge with action" in a governance context (Wyborn, 2015b). The latter application entails conceptualizing governance as a process of coproduction that involves the simultaneous employment of material, cognitive, social, and normative capacities (Wyborn, 2015b). The merit of this way of theorizing is that it conceptualizes knowledge as inherent to governance, thus lending insight into the roles of knowledge as a constitutive element of governance. However, it draws strong analytical divisions between knowledge, values, and social aspects by defining them in terms of distinct capacities (e.g., cognitive capacity, normative capacity, social capacity). The analytical framework that this paper elaborates and applies provides a stronger analytical sensitivity to the intertwinements of knowledge, values, and social order, as it conceptualizes particular governance capacities as being constituted by the interplay of epistemic, normative, and social elements. The next section will provide a further operationalization of this conceptual framework based on the environmental governance literature. Table 1 summarizes the next section by providing a structured overview of the

Table 1
Conceptual framework.

		Elements of governance capacities		
		Epistemic	Normative	Social
Governance capacities	Regulatory	• Knowledge creation and mobilization as enablers or constituents of regulation	• Goals • Visions • Limits	• Rules • Power • Modes of governance
	Adaptive	• Monitoring and understanding environmental change • Learning	• Willingness and opportunity to adapt or revise decisions	• Adaptive decision-making • Flexible arrangements • Iterative processes
	Integrative	• Incorporation of a variety of knowledge forms • Incorporation of diverging knowledge systems	• Incorporation of diverging values and normative frames	• Joint knowledge creation processes • Organized reflection on normative frames and epistemological beliefs

epistemic, normative, and social elements of the three governance capacities. These elements are not so neatly separated as this table may suggest; they are interrelated, imply each other, and may overlap.

2.2. Governance capacities

2.2.1. Regulatory capacity

Environmental governance involves organizing and steering collective action[2] in order to deal with environmental problems and conflicts (Paavola, 2007; Tacconi, 2011; Driessen et al., 2012). Thus, performing environmental governance requires regulatory capacity, which I define as the capacity to steer collective action with respect to the environment in desired directions.[3] This involves the formulation and pursuance of normative goals or visions, such as objectives laid down in environmental regulations or policies, or normative visions that have been formulated in the context of collaborative practices (Wyborn, 2015b). Moreover, it may involve the enactment of normative limits, such as "natural limits" that determine to what extent natural resource use is possible without critically compromising ecosystem integrity (Swart & Van der Windt, 2012).

This paper focuses on governance arrangements as the locus in which governance capacities are built and put into action. Governance arrangements are temporary assemblages that combine the employment of coalition-building, power, discourses and rules in order to govern collective action (Arts et al., 2006). Of these four aspects, power and rules are the most closely and observably related to regulatory capacity. Power is both "the ability of actors to mobilise resources in order to achieve certain outcomes in social relations" and a "dispositional and a structural phenomenon of social and political systems" (Arts & Van Tatenhove, 2004: 343). Rules may for instance include national and international legislations and rules that are laid down in collaborative agreements such as covenants.

Governance arrangements may encompass various ways in which knowledge and governance are interconnected. For instance, the ability to govern presupposes a "knowledge base" that informs decision-making; such a knowledge base for instance includes data, models, and practical experiences (Janssen et al., 2015: 313). However, governance arrangements may also encompass more intricate ways in which knowing and governing are interconnected. Power and knowledge for instance have been argued to constitute and imply each other; the exercise of power in a governance context necessarily involves knowing, just as much as producing knowledge for governance cannot be seen as independent of power relations (Van Assche et al., 2011; Winkel, 2012). Furthermore, rules laid down in environmental regulations and policies can structure the ways in which environmental issues are made knowable and measurable (Turnhout et al., 2014; Floor et al., 2016).

The social organization of governance arrangements may come in various forms; this variation is highlighted in terms of different "modes of governance" (Driessen et al., 2012). Modes of governance are particular ways in which governance arrangements are structured; they include *centralized governance* in which national governments "take the lead", *decentralized governance* in which regional or local governments are in the lead, *interactive governance* in which governments and societal actors "collaborate on equal terms", and *self-governance* in which societal actors "enjoy far-reaching autonomy" (Driessen et al., 2012: 145, 148). Because these different modes of governance involve different divisions of competences and power among actors, they represent different ways in which collective action is organized and regulated. In this sense, they can be interpreted as different ways of organizing and tapping into regulatory capacity.

2.2.2. Adaptive capacity

The governance of complex social-ecological systems entails dealing with issues of environmental change, uncertainty, and unforeseen consequences of human interventions in nature (Folke et al., 2005). This requires environmental governance arrangements to be adaptive. Adaptive governance involves the capacity to "understand environmental change", "use this understanding to inform decision making", and "act on decisions in a manner that sustains resilience of desirable system states" (Evans et al., 2011: 21). Moreover, it involves the capacity to "review and adapt decisions as new information becomes available" (Cvitanovic et al., 2015: 26). Consequently, gathering knowledge through monitoring and learning from both ecosystem change and the effects of management interventions in natural systems are conceived to be key epistemic aspects of adaptive governing (Termeer et al., 2010; Weiss et al., 2012). On a normative level, adaptive governance requires the willingness to adapt or revise decisions in the light of changing circumstances.

In the adaptive governance literature, two key forms of learning are discerned. Firstly, due to its collaborative and participatory character, adaptive governance entails learning as a multi-actor process; this type of learning is also referred to as "social learning" (Pahl-Wostl et al., 2007; Rijke et al., 2012). The term social learning is used to denote changes in understanding that occur through social interactions and that become situated in social settings or practices (Reed et al., 2010). Secondly, in order to enable the adaptive capacity of governance arrangements, learning is to take place by means of feed-back loops between natural systems and adaptive governance arrangements (Berkes, 2010; Evans et al., 2011; Giebels et al., 2013; Wilson et al., 2013). These forms of learning may be enhanced by means of flexible governance arrangements and iterative governance processes (Clarvis and Engle, 2015). Consequently, knowledge creation, learning, openness to change, and flexible and adaptive social processes together constitute adaptive governance capacity.

2.2.3. Integrative capacity

In this paper the term integrative capacity signifies the capacity to gain insight in diverging knowledges and normative perspectives and to bridge or integrate these for the sake of collaborative action with respect to the environment. Such capacity is required as environmental governance is usually a process in which different knowledgeable actors with different backgrounds, interests, and ideas are (expected to be) involved. Such knowledgeable actors may include citizens, scientists, NGOs, companies, and policy-makers (Birkenholtz, 2008; Edelenbos et al., 2011; Mauelshagen et al., 2014). Consequently, in environmental governance different knowledges and values meet and are confronted with each other.

A variety of concepts to distinguish between such differing knowledges can be found in the literature. Firstly, various conceptual distinctions have been applied in order to highlight the different forms or types of knowledge that may be relevant for environmental governance. For example, distinctions between scientific or expert knowledge and other forms of knowledge have often been highlighted (Birkenholtz, 2008; Berkes, 2009; Crona & Parker, 2012; Taylor & De Loë, 2012). Such "other" forms of knowledge include local and indigenous knowledge; these terms usually signify forms of knowledge that resource-users have accumulated through close and long-standing interactions with the local environment (Ellis, 2005; Crona & Bodin, 2010; Taylor & De Loë, 2012; Bowie, 2013; Linke & Bruckmeier, 2015). Secondly, various concepts have been used to give expression to the idea that different or conflicting knowledges are embedded in different social and normative configurations. One of these concepts is the "knowledge system", which signifies a social system encompassing knowledge claims, groups of actors, and ways of creating and exchanging knowledge; these elements together constitute a particular worldview or

[2] The term collective action in this paper refers to forms of human action with respect to the environment, such as the utilization and conservation of resources, in which multiple actors or collectives are involved.

[3] This paper uses the term "regulatory" in a relatively broad social-scientific sense. It not only denotes legal forms of regulation but also other ways in which human action may be steered, organized, or directed.

perspective on reality (Evans, 2010; O'Toole & Coffey, 2013). From this conceptual point of view, one of the key challenges of governance is to find fruitful linkages between conflicting knowledge systems, such as those of resource users and conservationists (King, 2004; Robinson and Wallington, 2012). A related line of environmental governance research focuses on the different "ways of knowing" of different coalitions of actors who are involved in governance (Janssen et al., 2015). Different ways of knowing "give rise to different understandings of precisely which factual knowledge is valid and relevant; they feed different world views, problem perceptions, and values" (Van Buuren, 2009: 209).

The literature that highlights different knowledges in the context of environmental governance suggests a number of ways in which the integrative capacity of governance arrangements may be built and put into action. Firstly, this may involve the integration or inclusion of various knowledges in governance, for instance by organizing joint knowledge creation processes in which various actors such as researchers, policy-makers, and stakeholders "cooperate in the exchange, production and application of knowledge" (Hegger et al., 2012: 53). Secondly, this may involve explicating and reflecting on the often implicit "normative frames of reference" that actors with various backgrounds have (Van Buuren, 2009: 215). Thirdly, it may involve the identification and awareness of "the different epistemological beliefs which underpin knowledge claims", such as beliefs concerning "the validity and reliability of different knowledge claims" (Raymond et al., 2010: 1775).

3. Materials and methods

3.1. Policy context and cases

3.1.1. Governance of the Wadden Sea area

This paper is empirically informed by research on the roles of knowledge in three domains of governance in the Dutch Wadden Sea area. The Wadden Sea area, which stretches from the northern coast of the Netherlands to the western coast of Denmark, encompasses tidal flats, salt marshes, and islands. Since the 1970 s, it has been increasingly protected under a combination of management initiatives and (inter)national regulations, including the Natura 2000 framework of the European Commission[4]. It is nowadays widely recognized as an important nature area, which is exemplified by its inscription on the UNESCO World Heritage list in 2009[5]. Moreover, its natural resources make the area valuable for various social-economic activities, such as shellfish fisheries, recreation, and gas and salt mining. This intensification of nature conservation has been accompanied by a rise of conflict and controversy between governmental agencies and various groups of NGOs and stakeholders, about the possibly negative impact of human activities in the area (Swart & Van der Windt, 2005; Runhaar & Van Nieuwaal, 2010). In recent years, various governance arrangements have emerged that aim at dealing with these conflicts by means of collaboration and negotiation between interested governmental and non-governmental organizations. The empirical basis of this paper encompasses studies of such collaborative arrangements in three domains: the mussel fishery, recreational boating, and coastal protection.

3.1.2. The mussel fishery

The mussel fishery in the Dutch Wadden Sea was the object of a longstanding and heated conflict between the mussel sector, the Dutch government, and a group of environmental protection NGOs (Van der Molen et al., 2015). This conflict, which went through some of its most intense phases between 1990 and 2008, revolved around the question whether the mussel fishery could be attuned to, or reconciled with, nature conservation. Court cases instituted by the NGOs forced the mussel sector to switch to fishing methods with a lower ecological impact. As a result, a governance arrangement was started in 2008 in which the parties involved work together in a stepwise transition towards more sustainable mussel fishing methods that inflict less damage to the seabed. This arrangement includes a collaborative monitoring and research program, which aims at dealing with knowledge conflicts and providing a shared knowledge base for the transition process.

3.1.3. Recreational boating

The rise of recreational boating on the Wadden Sea in recent decades has caused concerns among nature conservationists and policymakers about its impact on bird and seal populations (Van der Molen et al., 2016). In order to control this impact, several legal regulations, collaborative agreements between governmental and societal organizations, and self-regulation initiatives have been implemented since the 1980s. The implementation of regulations has spurred conflicts between recreational boating organizations, environmental NGOs, and the government about the effectiveness and necessity of nature conservation measures. In recent years, ongoing deliberations and more interactive and adaptive forms of management have helped to deal with these conflicts.

3.1.4. Sand nourishment

In order to counter coastal erosion, the Dutch government started a new coastal protection program in 1990 that involves sand nourishment (Van der Molen et al., 2018). The latter entails collecting sand from deeper parts of the North Sea and depositing it close to the shoreline or on the beach. A coalition of environmental protection NGOs criticized the sand nourishment program because they argued that it insufficiently took ecological aspects into account. After various legal actions by this coalition, a collaborative governance arrangement with the government was started. A key element of this arrangement is a research program on the ecological effects of sand nourishments, which is to provide insight into the optimization of sand nourishments with respect to nature.

3.2. Methodology

The empirical part of this paper is a comparative analysis of three case studies of knowledge-governance relations in the domains described above[6]. In all three studies, semi-structured interviews were a main method of data collection. I tried to interview as many actors as possible who were actively involved in the deliberations connected to the selected cases. These actors mainly include civil servants, researchers, and representatives of economic sectors, societal interest groups, and environmental protection NGOs. Candidate respondents were identified on the basis of both written sources and snowball sampling. The interview questions were fine-tuned for each case; however, all the interviews focused on a common set of main topics. These topics are: actors' perspectives on key issues regarding the case, interactions between the actors involved, the emergence and workings of governance arrangements, and the roles of knowledge in governance. The 69 interviews were recorded, transcribed verbatim, and analyzed on a case-to-case basis with software for qualitative data analysis (NVIVO 10). In all three cases, setting-specific codes were constructed on the basis of the issues that were brought up by the respondents (Lofland et al., 2006). In the case studies on the mussel fishery and recreational boating, focus groups were used as an additional data collection method. The set-up of the focus groups was based on the methods of the Reflexive Monitoring in Action approach (Van Mierlo et al., 2010). Furthermore, as a validation mechanism, I performed methodological triangulation in all three cases (Stake, 1995). For this

[4] http://ec.europa.eu/environment/nature/natura2000/index (last accessed on 11-16-2017)

[5] http://whc.unesco.org/en/list/1314 (last accessed on 11-16-2017)

[6] This section is partly adapted from (Van der Molen, 2017).

triangulation, I combined the interview and focus group data with relevant written sources such as legal texts, agreements and covenants, policy reports, workshop and meeting reports, and research and evaluation reports. Further details about the methodology, sources, and results of the three case studies are provided in separate papers (Van der Molen et al., 2015, 2016, 2018). For this paper, the results of the three studies were analyzed and compared, using the analytical framework described in Section 2. This analysis focused on cross-case patterns regarding how the three capacities were built and applied, and what roles knowledge played in these processes.

4. Empirical findings

4.1. Building regulatory capacity

In all three domains, governance arrangements have emerged that aim at attuning human activities in nature, such as fisheries and recreation, to nature conservation objectives. The findings indicate that, across the studied domains, there are two main normative "driving forces" behind this development. Firstly, knowing, appreciating, conserving, and restoring nature have gradually become more prominent in governing human activities and interventions in the Wadden Sea area. This is exemplified by the rise of various nature conservation regulations (see section 3.1.1), the increasing attention for knowledge dissemination among sailors in order to promote responsible boating, and the efforts to combine a sustainable mussel fishery with nature conservation and restoration (see also Van der Molen et al., 2015, 2016). Secondly, all three cases show an emerging focus on balancing the utilization and conservation of nature in such a way that the level of conflict between these two objectives, and between the actor coalitions who promote these objectives, is kept as low as possible. Various governance arrangements have emerged that are normatively oriented towards harmonizing the intervention in and protection of coastal nature.

In the three studied domains, centralized governance has played a key role in nature conservation; in addition, various interactive governance arrangements were implemented in the last decade. This rise of interactive governance can be seen as a shift of social order, which has encompassed empowering stakeholders, starting collaborations between societal and governmental actors on relatively equal terms, governing according to negotiated and mutually agreed-upon rules of the game, and refraining from taking legal action in dealing with conflicts.

As Table 2 shows, knowledge has played multiple roles in enabling and using regulatory capacity. These include: using legally required environmental impact assessments as a means of regulating and challenging human activities in nature, using collaborative research and monitoring as means of steering human activities towards the sustainable utilization of natural resources, and using the dissemination of knowledge and the building of awareness as means of promoting ecologically responsible behavior.

4.2. Building adaptive capacity

The three cases show that adaptive capacity can be an important aspect of environmental governance in various ways (Table 3). For instance, flexible and adaptive forms of governance have been implemented in all three domains, in order to be able to respond to natural dynamics, such as changes in mussel stock, coastal erosion, and the occurrence of wildlife. Furthermore, the mussel fishery case shows that adaptive capacity, in the form of a flexible and adaptive transition process, may facilitate working towards shared sustainability objectives in situations in which stakeholder conflict and uncertainty about the effects of human intervention in nature (e.g. new fishing methods and conservation measures) play a role. Finally, the recreational boating case illustrates that adaptive capacity may take the shape of long-term governance improvement, which can be enabled by temporary and experimental governance arrangements, such as temporary collaborative agreements and action plans.

Across the three domains, three main ways in which knowledge enables adaptive capacity can be found. Firstly, all three studies show that monitoring is a crucial enabler of adaptive capacity, because adaptation requires up-to-date knowledge of changing circumstances. Secondly, in all three domains learning-oriented forms of governance have played an important role in responding to change. This is exemplified by the learning-by-doing approach that was followed in the mussel fishery case, and by the application of experimental forms of management, such as the use of pilots and experiments with new management approaches in the case of recreational boating. The latter case also shows that adaptive capacity may be enabled by implementing temporary governance arrangements that are followed by evaluations. This may enable learning and governance renewal in the long run.

4.3. Building integrative capacity

In the domains that have been studied, various groups of stakeholders with diverging concerns and values, and often also with diverging epistemological perspectives, have been involved. Particularly in the mussel fishery case, such diverging perspectives have played an important role in the conflict and debate about the future of the mussel fishery in the Dutch Wadden Sea (Van der Molen et al., 2015). In all three domains, the integrative capacity to deal with the conflicting normative and epistemological perspectives has been built by setting up governance arrangements that provide for the sustained and iterated

Table 2
Ways of enabling regulatory capacity.

	Ways of building and applying regulatory capacity	Roles of knowledge
The mussel fishery	• Using a legal permit system to regulate the mussel fishery. • Challenging permits in court in order to attune the fishery to nature conservation. • Collaborate in order to reach shared sustainability objectives. • Using an interactive, participatory governance arrangement in addition to the centralized permit regime.	• Using legally required ecological assessments to prove that fishery has no significant ecological effect on nature. • Disputing the proof that is provided in the assessments in order to better attune the fishery to nature conservation (by NGOs). • Executing a joint research and monitoring program in order to enable a transition towards sustainable fishing methods.
Recreational boating	• Implementing decentralized and interactive governance in addition to centralized governance and regulations, in order to find a balance between nature conservation and utilization. • Applying self-governance, i.e. voluntary rules and codes of conduct for sailors, in order to stimulate responsible boating.	• Using monitoring as a key knowledge source for regulation. • Sharing knowledge and building awareness as important instruments for stimulating responsible behaviour among sailors.
Sand nourishment	• Using legal procedures to challenge the existing coastal protection program. • Incite the coastal management department of the government to request permits for sand nourishment under the nature protection regulations. • Collaborate according to a covenant, which contains agreements on settling disputes and executing joint research.	• Using legally required ecological impact assessments as means of attuning sand nourishments to nature conservation objectives. • Executing joint ecological research in order to optimize sand nourishments with respect to nature conservation.

Table 3
Ways of enabling adaptive capacity.

	Ways of building and applying adaptive capacity	Roles of knowledge
The mussel fishery	• Using a flexible, stepwise transition process towards more sustainable fishing methods. The speed of the transition is contingent upon both natural variability and the success of new fishing methods.	• Monitoring mussel stock and yield in order to inform adaptive management. • Learning by doing, experimenting with fishing methods and nature conservation measures.
Recreational boating	• Adaptively closing off and throwing open nature areas, depending on bird and seal occurrence, in order to both protect wildlife and enable recreation. • Ongoing renewal of governance arrangements and regulatory approaches towards increased flexibility and adaptation.	• Evaluating and learning from temporary and flexible governance arrangements in order to enable the improvement of governance. • Pilots and experiments to try out new forms of regulation. • Monitoring recreation and wildlife to inform adaptive management.
Sand nourishment	• Using sand nourishment as a form of adaptive and dynamic coastal engineering.	• Enabling learning about ecology-oriented coastal management through case-studies and experimenting with “green sand nourishments”.

Table 4
Ways of enabling integrative capacity.

	Ways of building and applying integrative capacity	Roles of knowledge
The mussel fishery	• Using a covenant to manage conflict and create a collaborative setting. • Organizing frequent interactions and deliberations between the mussel sector, NGOs, and government, to find common ground between their clashing perspectives.	• Using a joint fact finding process to find common ground between diverging perspectives of mussel sector and NGOs. • Engage in a joint research and monitoring program to create shared knowledge. • Involve experts who are trusted by all parties in the research and monitoring program.
Recreational boating	• Achieving network-building and rapprochement between actor groups, by means of sustained participation and deliberation in collaborative governance arrangements. • Implementing pragmatic and flexible forms of regulation that meet the demands of both recreational boating organizations and nature conservation NGOs.	• Sharing knowledge between recreational boating organizations and nature conservation NGOs, in order to create a common perspective on recreation and conservation. • Participatory monitoring with sailors and conservationists as a way of enabling collaboration.
Sand nourishment	• Using a covenant to manage conflict and create a collaborative setting.	• Programing and executing a participatory research program on ecology-oriented sand nourishment in order to address the concerns of all parties involved.

collaboration and deliberation between the various stakeholders. Many of the arrangements that have emerged in these domains have an interactive character, i.e. they provide settings in which involved actors can collaborate and deliberate on a relatively equal footing.

Within these arrangements, knowledge has enabled integrative capacity in several ways (Table 4). Firstly, in all three cases, joint knowledge creation processes have been used to produce knowledge that matches the concerns and perspectives of the different actors involved. Examples of this are collaborative monitoring in the recreational boating case, and jointly programed and executed ecological research in the other two cases. Secondly, knowledge exchange between stakeholders has facilitated finding common ground between diverging perspectives, for instance in the domain of recreational boating. Thirdly, the involvement of independent experts has contributed to dealing with conflicting perspectives, for instance by providing independent reviews of the available knowledge.

5. Discussion and conclusion

Like environmental governance initiatives in many places around the world, the governance arrangements described in this paper have sought to attune various human interventions in nature to the conservation and restoration of nature. These arrangements have aimed to reach this objective by means of settling conflicts between governments, resource users, and conservationists, and by means of working towards objectives that meet the various concerns of these groups of actors.

This paper has argued that settling such conflicts and working towards sustainable human-environment relations is a multifaceted process that encompasses various forms of capacity building. Firstly, my analysis suggests that the regulatory capacity towards such aims may be built by engaging in interactive governance, which involves the active involvement and empowerment of societal stakeholders and negotiating and implementing mutually agreed-upon rules. Moreover, it suggests that such interactive governance processes do not replace but rather complement more hierarchical, centralized forms of governance such as governance arrangements that are connected to nature conservation legislations. Secondly, my analysis highlights various ways in which adaptive capacity may enable the sustainable governance of nature. For instance, adaptive capacity may enable responsive forms of governance that are able to adapt to dynamic natural systems, and may facilitate working towards shared objectives under conditions of uncertainty and lacking knowledge. Moreover, adaptive capacity may enable the long-term improvement of governance through the ongoing evaluation and renewal of temporary governance arrangements. Thirdly, the three cases show that integrative capacity may be built by means of governance arrangements that provide for the sustained and iterated collaboration and deliberation between various groups of stakeholders. My findings suggest that building integrative capacity requires both the reflection on diverging epistemic and normative perspectives among interested actors and a shared desire among these actors to somehow bridge or integrate their perspectives. Such bridging and integration may be facilitated by interactive knowledge processes such as knowledge exchange and joint knowledge creation. From this analysis may be concluded that settling disputes about natural resources and working towards a sustainable equilibrium between conserving and utilizing nature may be enabled by means of interactive and flexible governance arrangements that complement centralized governance and that provide spaces for joint knowledge creation and knowledge exchange. However, sustaining such arrangements may be challenging because it requires the long-term, intensive and often voluntary involvement of various groups of actors with diverging interests.

The relations between environmental knowledge and various forms

of environmental politics and action, such as management, policy-making, and governance, have received ample scholarly attention in recent decades. A prominent tradition within this scholarship conceptualizes these relations in terms of the boundaries and interfaces between environmental knowledge and governance (Clarke et al., 2013; Wesselink et al., 2013; Jordan, 2014; Wyborn, 2015a). From this perspective, realizing well-informed governance requires the successful organization and management of interfaces between for instance experts and decision-makers or scientific and political institutions (Robinson and Wallington, 2012; Bremer & Glavovic, 2013). However, there is more to knowledge-governance relations than the organization and management of interfaces. This paper has aimed to elaborate an additional perspective that provides an analytical sensitivity to aspects of knowledge-governance interrelations that have received less attention in the literature. The rationale of this perspective is that knowledge can be understood to be an intrinsic part of governance; moreover, knowledge can be understood to be a constitutive element of the various capacities that are needed in order to govern sustainable human-environment interactions. This perspective builds on environmental governance scholarship that highlights the intertwined and hybrid nature of knowledge and power, which includes research in the tradition of interpretive policy analysis (e.g., Wesselink et al., 2013) and governance studies inspired by the work of Michel Foucault (e.g., Van Assche et al., 2011; Winkel, 2012). Furthermore, my findings suggest that the notion of coproduction, in the sense of the combined and interconnected creation of knowledge and social order, is a useful concept for investigating the various enabling roles that knowledge may play in environmental governance (see also Chilvers & Kearnes, 2015; Wyborn, 2015b).

The results indicate that this additional perspective on knowledge-governance interactions has several merits. Firstly, it incites us to rethink the very notion of environmental governance. The literature often emphasizes that governance is a collaborative process of policy-making and regulation in which both governmental and non-governmental actors are involved (Wallington et al., 2008; Klinke, 2012; Bixler, 2014). However, this paper suggests that it is also an essentially epistemic process. This means that environmental governance encompasses various forms of knowledge, various ways of knowing, and various knowledge-related dynamics and processes. Secondly, it helps to identify particular ways in which knowledge constitutes environmental governance capacities. The findings suggest that knowledge may serve as a steering mechanism for governance, for instance by using environmental impact assessments as a tool for improving the ecological soundness of human interventions in nature, or by using the building of knowledgeability and awareness as nature conservation instruments. Furthermore, well-informed environmental governance is constituted by learning, which may involve experimenting, learning by doing, and using temporary governance arrangements to enable governance renewal. Finally, knowledge may serve as a connective element of environmental governance. In the cases analyzed here, notably joint knowledge creation, knowledge exchange, and the involvement of experts have enabled collaborations between actors with different normative perspectives on how to utilize and conserve nature. These findings suggest that a strength of the analytical framework elaborated in this paper, is that it helps to gain insight into the multiplicity of roles that knowledge may play in performing environmental governance.

The framework of governance capacities that I have employed in this paper is an operationalization and application of the notion of the coproduction of knowledge and social order (Jasanoff, 2004). Jasanoff has argued that coproduction is not a "fully fledged theory, claiming lawlike consistency and predictive power", but rather "a way of interpreting and accounting for complex phenomena" (Jasanoff, 2004: 3). Likewise, the framework of the epistemic, normative, and social aspects of governance capacities is not a model with lawlike consistency or predictive power but rather a way of reasoning about the makings and workings of environmental governance. My findings suggest that this framework is useful for identifying the heterogeneous elements of knowledge, values, and social order that together constitute governance capacities. This paper has distinguished between regulatory, adaptive, and integrative capacities. This triad of governance capacities is notably applicable to environmental governance arrangements that face the challenges of dealing with dynamic and complex natural systems and dealing with a diversity of interested actors with diverging perspectives. Such challenges may occur in a variety of environmental governance domains, but need not always be as expressly present as in the cases described in this paper. Consequently, not all three capacities are necessarily needed in all environmental governance arrangements; moreover, the framework may be expanded with other governance capacities that did not play prominent roles in the cases studied here. Still, such additional capacities may be argued to be constituted by epistemic, normative, and social elements.

The framework presented in this paper also has shortcomings that could be addressed in further research. Firstly, the term coproduction has several distinct meanings in the literature; its application may come with the risk of conceptual vagueness or confusion (see also Hegger et al. 2012). It would be useful for future research to investigate how such confusion with respect to the notion of coproduction may be avoided. Secondly, the framework conceptualizes knowledge as an intrinsic element of governance. However, there are also situations in which divides between knowledge and governance occur (Runhaar & Van Nieuwaal, 2010). In its current form, the framework has limited analytical sensitivity to situations in which knowledge is external to, or excluded from governance.

A practical consequence of the way of reasoning I have elaborated in this paper is that building well-informed environmental governance arrangements is not just a matter of managing the interfaces between knowledge and governance; it is also a matter of capacity-building in order to enable the reflexivity of governance arrangements. Here, reflexivity has a twofold meaning. Firstly, it signifies the capacity to identify diverging normative and epistemic perspectives and to connect these perspectives to collaborative action with respect to the environment. Secondly, it signifies the capacity to gain insight into complex and dynamic natural systems and to respond to changes in an adaptive manner. My findings suggest that governance arrangements that combine these two forms of reflexivity may be enabled by a combination of negotiated rules, joint knowledge creation and knowledge exchange, adaptive and experimental governance, and interactions and deliberations between interested stakeholders.

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